

CLAIMS

The invention claimed is:

1. A single-solvent method of isolating and purifying all-*trans*- β -carotene from any plant material that contains carotenoids, wherein the same type of solvent is used in all steps utilizing a solvent, said method comprising:
 - (a) contacting said plant material for a selected period of time with said solvent, whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;
 - (b) collecting and filtering said crude extract;
 - (c) evaporating said solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said solvent;
 - (d) heating said substantially solvent free oil for a sufficient period of time and at a sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*- β -carotene isomers; and
 - (e) washing said oil with said solvent, whereby the all-*trans*- β -carotene isomers are crystallized.
2. The method of claim 1, wherein said solvent is heptane.
3. The method of claim 1, wherein said plant material is an algae.
4. The method of claim 3, wherein said algae is *Dunaliella salina*.
5. The method of claim 1, wherein said selected period of time is from about 10 minutes to 5 hours.
6. The method of claim 4, wherein said selected period of time is from 20 to 60 minutes.
7. The method of claim 3, wherein said algae is treated prior to said contacting step to remove emulsifying agents.
8. The method of claim 7, wherein said emulsifying agents are removed by ultra-filtration.
9. The method of claim 1, wherein said filtering step utilizes a filter having a pore size in the range of 1 to 100 μm .
10. The method of claim 1, wherein said evaporation step occurs at a temperature in the range of 80 to 100°C.
11. The method of claim 10, wherein said temperature is about 98°C.
12. The method of claim 1, wherein said heating step occurs at a temperature of 105° to 140°C.

13. The method of claim 12, wherein said temperature is 120°C.
14. The method of claim 12, wherein said heating step requires 1 to 24 hours.
15. The method of claim 13, wherein said heating step requires about 24 hours.
16. The method of claim 1, wherein said heating step comprises:
 - (a) heating said substantially solvent free oil to a temperature of about 140°C and maintaining said temperature at about 140°C for about one hour;
 - (b) reducing said temperature to about 110°C and maintaining said temperature at about 110°C for about one hour; and
 - (c) reducing said temperature to about 105°C and maintaining said temperature at about 105°C for about six hours.
17. The method of claim 1, wherein said solvent in said washing step is at a temperature of about -15° to 25°C.
18. A single-solvent method of isolating and purifying all-*trans*-β-carotene from any algal material that contains carotenoids, wherein the same type of solvent is used in all steps utilizing a solvent, said method comprising:
 - (a) removing emulsifying agents from said algal material;
 - (b) extracting said carotenoid compounds from said algal material by mixing said algal material with a solvent, whereby said carotenoids are solubilized and transported into said solvent forming a crude extract;
 - (c) collecting and filtering said crude extract;
 - (d) evaporating said solvent from said crude extract by heating said crude extract to a temperature of about 80 to 100°C, thereby forming an oil substantially free of solvent;
 - (e) heating said substantially solvent free oil to a temperature of about 105° to 140°C for about 1 to 24 hours to convert said carotenoids capable of being isomerized to all-*trans*-β-carotene isomers; and
 - (f) crystallizing said all-*trans*-β-carotene by washing said heated oil with said solvent, wherein said solvent for said washing is at a temperature of about -15°C to 25°C.
19. The method of claim 18, wherein said emulsifying agents are removed by ultra-filtration.
20. The method of claim 18, wherein said algal material is *Dunaliella salina*.
21. The method of claim 18, wherein said solvent is heptane.
22. The method of claim 18, wherein said evaporation step occurs at about 98°C.

23. The method of claim 18, wherein said heating step occurs at about 120°C.
24. A process for converting a substantially solvent free *cis*-carotene isomer to an all-*trans*-carotene isomer, comprising:
 - (a) subjecting the substantially solvent free *cis*-carotene isomer to an initial temperature of approximately 140°C and maintaining said temperature at about 140°C for about one hour;
 - (b) reducing said temperature to about 110°C and maintaining said temperature at about 110°C for about one hour; and
 - (c) reducing said temperature to about 105°C and maintaining said temperature at about 105°C for about six hours.
25. The process of claim 24, wherein said reducing steps (b) and (c) take place at a rate that maintains an optimum rate of *cis*-carotene isomer to *trans*-carotene isomer conversion.
26. The process of claim 24, wherein said *cis*-carotene isomer is β -carotene.
27. A single-solvent process for making both a first mixed carotenoid oil product and a second all-*trans*- β -carotene product from any plant material that contains carotenoids, wherein the same type of solvent is used in all steps utilizing a solvent, said method comprising:
 - (a) contacting said plant material for a selected period of time with said solvent, whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;
 - (b) collecting and filtering said crude extract;
 - (c) evaporating said solvent from said crude extract thereby forming an oil containing said first mixed carotenoid oil product, wherein said oil is substantially free of said solvent;
 - (d) heating said substantially solvent free first mixed carotenoid oil product for a sufficient period of time and at a sufficient temperature to isomerize the carotenoids in said first mixed carotenoid oil product capable of being isomerized to all-*trans*- β -carotene isomers; and
 - (e) crystallizing said all-*trans*- β -carotene isomers from said heated mixed carotenoid oil product by washing said heated mixed carotenoid oil product with said solvent, wherein said solvent is at a temperature of about -15°C to 25°C, whereby said second all-*trans*- β -carotene product is isolated.

28. The process of claim 27, wherein said solvent is heptane.
29. The process of claim 27, wherein said plant material is an algae.
30. The process of claim 27, wherein said selected prior of time for contacting said solvent with said plant material is from about 10 minutes to 5 hours.
31. A single-solvent method of isolating and purifying carotenoids from any plant material that contains carotenoids, wherein the same type of solvent is used in all steps utilizing a solvent, said method comprising:
 - (a) contacting said plant material with said single, non-acidic extraction solvent for a selected period of time, whereby said carotenoids are solubilized and *transported* into said non-acidic extraction solvent forming a crude extract;
 - (b) collecting and filtering said crude extract; and
 - (c) evaporating said non-acidic, extraction solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said non-acidic extraction solvent.
32. The method of claim 31, further comprising:
 - (d) heating said oil from step (c) for a sufficient period of time and at a sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*- β -carotene isomers; and
 - (e) washing said oil from step (d) with said non-acidic extraction solvent, whereby the all-*trans*- β -carotene isomers are crystallized.
33. The process of claim 31, wherein said non-acidic extraction solvent is heptane.
34. The process of claim 31, wherein said plant material is an algae.
35. The process of claim 31, wherein said algae is *Dunaliella salina*.
36. The method of claim 31, wherein said selected period of time is from about 10 minutes to 5 hours.
37. The method of claim 36 wherein said selected period of time is from 20 to 60 minutes.
38. The method of claim 34, wherein said algae is treated prior to said contacting step to remove emulsifying agents.
39. The method of claim 38, wherein said emulsifying agents are removed by ultra-filtration.
40. The method of claim 31, wherein said filtering step utilized a filter having a pore size in the range of 1 to 100 μm .

41. The method of claim 31, wherein said evaporation step occurs at a temperature in the range of 80 to 100°C.
42. The method of claim 41, wherein said temperature is about 98°C.
43. The method of claim 32, wherein said heating step occurs at a temperature of 105° to 140°C.
44. The method of claim 43, wherein said temperature is 120°C.
45. The method of claim 43, wherein said heating step requires 1 to 24 hours.
46. The method of claim 44, wherein said heating step requires about 24 hours.
47. The method of claim 32, wherein said heating step comprises:
 - (a) heating said oil from step (c) to a temperature of about 140°C and maintaining said temperature at about 140°C for about one hour;
 - (b) reducing said temperature to about 110°C and maintaining said temperature at about 110°C for about one hour; and
 - (c) reducing said temperature to about 105°C and maintaining said temperature at about 105°C for about six hours.
48. The method of claim 32, wherein said extraction solvent in said washing step is at a temperature of about -15° to 25°C.
49. A single-solvent method of isolating and purifying all-*trans*-β-carotene from any plant material that contains carotenoids, comprising:
 - (a) contacting said plant material for a selected period of time with said solvent, whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;
 - (b) collecting and filtering said crude extract;
 - (c) evaporating said solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said solvent;
 - (d) heating said substantially solvent free oil for a sufficient period of time and at a sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*-β-carotene isomers; and
 - (e) washing said oil with said solvent, whereby the all-*trans*-β-carotene isomers are crystallized, wherein the steps of this method all use the same solvent.
50. A method consisting of a single-solvent system for isolating and purifying carotenoids from a plant material containing carotenoids wherein the method comprises:
 - (a) contacting said plant material for a selected period of time with said solvent,

whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;

- (b) collecting and filtering said crude extract;
- (c) evaporating said solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said solvent;
- (d) heating said substantially solvent free oil for a sufficient period of time and at a sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*- β -carotene isomers; and
- (e) washing said oil with said solvent, whereby the all-*trans*- β -carotene isomers are crystallized.

51. A method for isolating and purifying carotenoids from a plant material containing carotenoids, comprising:

- (a) utilizing only one single solvent throughout the entire method;
- (b) contacting said plant material for a selected period of time with said solvent, whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;
- (c) collecting and filtering said crude extract;
- (d) evaporating said solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said solvent;
- (e) heating said substantially solvent free oil for a sufficient period of time and at a sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*- β -carotene isomers; and
- (f) washing said oil with said solvent, whereby the all-*trans*- β -carotene isomers are crystallized.

52. A method for isolating and purifying carotenoids from a plant material containing carotenoids, comprising:

- (a) contacting said plant material for a selected period of time with a solvent, wherein said solvent consists of the same type of solvent utilized throughout the entire method and whereby said carotenoids are solubilized and *transported* into said solvent forming a crude extract;
- (b) collecting and filtering said crude extract;
- (c) evaporating said solvent from said crude extract thereby forming an oil containing said carotenoids, wherein said oil is substantially free of said solvent;
- (d) heating said substantially solvent free oil for a sufficient period of time and at a

sufficient temperature to isomerize said carotenoids capable of being isomerized to all-*trans*- β -carotene isomers; and

(e) washing said oil with said solvent, whereby the all-*trans*- β -carotene isomers are crystallized.